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Evaluation of Protein Status of Lactating Dairy Cows

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Research Summary: SARF Project No. 5-85-41
Evaluation of Protein Status of Lactating Dairy Cows
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Feed costs make up approximately half of the cost of milk production. Protein is one of the most expensive nutrients in dairy cattle rations. This project was conducted to evaluate methods of measuring the adequacy of dietary protein in dairy cattle rations and to determine the effectiveness of dietary proteins of different solubility and rumen bypass characteristics. In the first year of this project, reported previously, the analysis of milk urea nitrogen was evaluated as a measurement of the protein status of dairy cows. It was found to have potential value and will be further examined in future trials and may be used in provincial testing and advisory services. In two projects conducted during the past year, an initial evaluation of high and low rumen bypass protein rations were conducted. A ration containing corn gluten meal and barley distillers' dried grains, which supplied a high proportion of rumen bypass protein, improved milk fat percentage and tended to improve milk yield, without an increase in feed consumption. In a second trial, whole canola seed, canola presscake and canola meal were compared. These feeds represent three different levels of rumen bypass potential. Although this study confirmed the value of milk and blood urea nitrogen in evaluating protein status, canola presscake and whole canola seed were found to be relatively poor sources of rumen bypass protein. This research as well as a review of other current research emphasises the importance of rumen bypass protein content in rations for high producing dairy cows. However, because there is no general agreement as to the levels and sources of bypass protein required for different levels of production, this research must be continued.

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Part 1

Dairy Cow Response To Bypass Protein

ABSTRACT

Protein which passes through the rumen of cattle and is digested and absorbed in the small intestine must be supplied to dairy cattle to meet their protein requirements. Only a limited number of feedstuffs have the required rumen bypass characteristics. Two of these feeds are corn gluten meal and distillers' dried grains. They have not been evaluated under Saskatchewan conditions. A high bypass protein concentrate was formulated containing approximately 10% of these two feeds and compared to a control ration in which the protein supplement was soybean meal and canola meal. Milk yield was increased by approximately 1 kg/day when the high bypass protein source was fed. Fat and protein percentages in the milk were increased by feeding rumen bypass protein. Bodyweight was maintained and feed intake was not increased when the high bypass protein ration was fed.

BACKGROUND

High producing dairy cows require high levels of protein intake, often more than is available from microbial protein. Bypass protein passes through the rumen without microbial degradation. True bypass protein is digested and absorbed in the small intestine without being changed in the rumen. Estimates of the bypass value of individual protein sources are not constant and can change with a number of ration variables such as total protein content, feeding methods and ration moisture levels. Some literature advocates that all protein above 10% of the ration dry matter should be bypass protein.

Feedstuffs that have been dried contain the largest percentage of bypass protein. These include dehydrated alfalfa, corn gluten meal, distillers' dried grains, meatmeal and fishmeal. Protein that has been heat damaged is not bypass protein and is unavailable to the animal.

OBJECTIVES

To replace part of the soybean meal in the concentrate with corn gluten meal and barley distillers' dried grains and to measure the response of lactating dairy cows to the increased proportion of dietary "bypass" protein.

EXPERIMENTAL PLAN

Four cows in early lactation were fed 2 rations in a switchback design feeding trial with three 21 day periods. The concentrate portion of the rations contained:

1) A low level of bypass protein. This was the standard Greenbrae dairy concentrate (21% CP in DM).

2) A higher level of bypass protein. This was concentrate (1) with the soybean meal partially replaced by corn gluten meal and barley distillers' dried grains.

Both concentrates were pelleted and fed with barley silage in a silage:concentrate ratio of 45:55 on a hay equivalent basis.

RESULTS AND DISCUSSION

The composition of the high bypass protein sources is given in Table 1. The percent bypass protein estimations are from the available literature. The estimated percent bypass protein in corn gluten meal and barley distillers' dried grains is 44 and 19 respectively (dry matter basis). The estimated percent bypass protein in soybean meal is approximately 12.

The current Greenbrae dairy concentrate was used as the low level bypass concentrate (Table 2). It was desirable to change as few ingredients as possible from the low to high bypass protein concentrate.

The concentrates contained a higher percentage of crude protein than the 21% (dry matter basis) that they were formulated to contain (Table 3). This was probably due to higher than anticipated levels of crude protein in the grain portion of the concentrates. There was 12.5% crude protein in the barley silage dry matter. The low and high bypass rations contained 18.7 and 19.3% crude protein and 4 and 5.3% bypass protein (dry matter basis). Therefore the low and high rations contained 14.7 and 14 percent non-bypass protein.

Cows fed the high bypass protein ration produced a significantly ($P<0.05$) higher percentage of milk fat (Table 4). All cows produced low fat percentage milk which is a result of feeding pelleted concentrates. The cows fed the high bypass rations tended to produce more milk with a slightly higher protein content and milk protein produced (kg/day) tended to be higher ($P<0.10$).

Total feed intake was the same for both rations (Table 5). It required less feed DM to produce 100 kg of 4% fat corrected milk with the high bypass ration. Blood urea nitrogen was measured at 2 hours post feeding. The significantly higher ($P<0.10$) value for the high bypass rations may reflect less protein loss in the rumen.

Total protein was fed at one and a half times the requirement (Table 6). The concentrate portion of the ration theoretically supplied more than the requirement.

CONCLUSIONS

The ration containing a higher proportion of bypass protein did improve milk fat percentage and tended to improve milk yield without an increase in dry matter consumption. Further studies should be undertaken in determine the effect of bypass protein in rations containing less total protein than fed in this experiment and a higher proportion of the total protein as bypass protein.

IMPACT ON INDUSTRY

Bypass protein has potential to improve the efficiency of high producing dairy cows.

Table 1. Composition[1] of bypass protein sources

	% DM	% in dry matter					
		CP	ADF	ADF-N[2]	Ca	P	% BPP[3]
Corn gluten meal	92.4	67.5	12.5	1.2	.48	.46	65
Distillers' dried grains	89.4	32.2	20.5	0.6	.01	1.21	60

[1]From laboratory analyses of feedstuffs.

[2]ADFN is the % of total nitrogen unavailable for digestion. % CP=N x 6.25.

[3]Refers to the average percentage of the crude protein that passes through the rumen without microbial degradation. From Preston, R.L. 'Typical Composition of Feeds for Cattle and Sheep 1984-85' in Feedstuffs August 27, 1984

Table 2. Concentrate ingredients (% air dry basis)

	Low Bypass Protein Conc	High Bypass Protein Conc
Barley	50.0	50.0
Wheat	10.0	10.0
Oats	10.0	10.0
Soybean Meal	16.0	5.6
Canola Meal	5.5	5.5
Whole canola	0.6	0.6
Corn gluten meal	----	7.5
Barley distillers' dried grains	----	2.7
Urea	0.5	0.5
Molasses	3.0	3.0
Dicalcium phosphate[1]	1.5	1.7
Limestone	1.1	1.1
Cobalt-iodized salt	0.8	0.8
Mineral-vitamin premix[2]	1.0	1.0

[1]Calcium-phosphorus source 15% Ca, 21% P.

[2]To supply 13,200 IU Vitamin A, 1100 IU Vitamin D, 11 IU Vitamin E, 20 mg manganese, 40 mg zinc, 12 mg copper per kg concentrate. Also contains ethoxyquin at 0.015% of concentrate.

Table 3. Composition[1] of experimental feedstuffs

	in dry matter						
	% DM	% CP	% ADF	% Ca	% P	GE kcal/kg	% BPP[2]
Low bypass conc	90.8	23.8	7.5	.86	.79	4.46	4.7
High bypass conc	90.9	24.9	7.4	.97	.91	4.59	7.1
Barley silage	34.5	12.5	31.2	.46	.39	----	3.2

[1]From laboratory analyses of feedstuffs.

[2]Calculated amount of total bypass protein as a % of dry matter - from actual crude protein content of ingredients and literature bypass estimations.

Table 4. Effect of bypass protein on milk yield and composition

	Low Bypass Protein Ration	High Bypass Protein Ration	SEM
Actual milk yield, kg/day	33.0	34.2	.47
% milk fat	1.99[a]	2.11[b]	.02
Milk fat, kg/day	.66	.72	.02
4% fcm yield, kg/day	23.5	24.5	.51
% milk protein	3.24[1]	3.34[2]	.10
Milk protein, kg/day	1.07	1.14	.02
% total solids	11.08	11.32	.11

[a-b]Means in the same row with different superscript letters are significantly different ($P<0.05$).

[1-2]Means in the same row with different superscript numbers are signficantly different ($P<0.10$).

Table 5. Effect of bypass protein on feed intake and utilization

	Low Bypass Protein Ration	High Bypass Protein Ration	SEM
Silage DM intake, kg/day	9.1	9.1	.19
Concentrate DM intake, kg/day	12.1	11.9	.14
Total DM intake, kg/day	21.1	20.9	.32
Feed DM intake/100 kg FCM, kg	91.8	86.3	2.39
Bodyweight change, g/day	390	420	162
BUN, mmol/L	7.4[1]	7.8[2]	.10

[1-2]Means in the same row with different superscript numbers are significantly different ($P<0.10$).

Table 6. Crude protein requirement and intake of cows fed low and high bypass rations

	Low Bypass Protein Ration	High Bypass Protein Ration	SEM
Crude protein req't, g/day	2723	2841	46.1
Crude protein intake, g/day	4013	4109	66.7
Crude protein intake from silage, g/day	1138	1148	27.8
CP intake from conc, g/day	2875	2961	40.7
CP intake, % CP req't	147.4	145.0	3.6
Bypass protein from conc, g/day	572^{A}	842^{B}	17.1
Conc BPP, % total CP intake	14.2	20.6	.05

$^{A-B}$Means in the same row with different superscript letters are significantly different ($P<0.01$).

Part 2

The Utilization of Canola Presscake in Rations for Lactating Dairy Cows

ABSTRACT

In previous studies, canola meal has been found to have about the same rumen bypass value as soybean meal. Whole canola seed and canola presscake are two potential ingredients for dairy cattle rations. Canola presscake is an intermediate product in the extraction of oil from canola seed. Four rations were formulated to compare these protein sources. Protein in whole canola seed and in presscake was found to be more rapidly degraded in the rumen than canola meal protein. Four percent fat corrected milk yield tended to be lower when whole canola seed or presscake was fed. The addition of canola oil to the ration also tended to reduce milk production.

BACKGROUND

Canola presscake is a potential by-product of the canola processing industry. It is derived from canola seed that has undergone the physical, but not the solvent extraction. It contains 21% ether extract (crude fat), in contrast to the 2% remaining in canola meal (Table 1). Although heat is required in both stages of the extraction process, conditions tend to be more severe in the final extraction. Increased levels of ether extract allow rations to be formulated with the energy and fiber levels required for a high producing dairy cow. However, the incorporation of significant amounts of oil into dairy rations has met with varible success. Long chain fatty acids appear to have detrimental effects on the rumen metabolism. This has been alleviated somewhat by including the fat in the form of a crushed seed, or adsorbed onto a carrier. Heating has been shown to reduce protein solubility increasing the intestinal supply of dietary amino acids (by-pass protein).

OBJECTIVES

To determine the production response of lactating dairy cows to the inclusion of canola presscake in their diets.

To examine the effect of including canola oil in the ration as a free oil or contained within the seed.

EXPERIMENTAL

Three Latin square design feeding trials were conducted utilizing four animals each. A barley-based concentrate was used as a control. Treatment concentrates were formulated to contain 6% ether extract. This was achieved with the addition of:

1. 3.45% canola oil
2. 22% canola presscake
3. 9.1% whole canola seed

The concentrates were formulated to meet NRC (National Research Council, 1978) requirements for crude protein and energy and 120% of the NRC (1978) requirements for calcium and phosphorus. The concentrates were fed in a 1:1 ratio with either hay or silage on a dry matter basis (Table 2).

The performance of first lactation heifers fed silage was compared to the performance of heifers fed hay. The response between heifers and cows fed the hay was also compared.

The in situ nylon bag producedure was utilized to determine dry matter and crude protein disappearance rates of whole canola seed, canola presscake and canola meal. Samples were incubated for 4, 8 and 12 hours periods. Two non-lactating rumen fistulated cows were used for this procedure.

RESULTS AND DISCUSSION

An initial palatability trial with the presscake diet indicated no palatability or feed intake problems. One of the cows developed pica, indicative of a phosphorus deficiency. Blood phosphorus concentrations were low in two of the cows. Top-dressing with dicalcium phosphate alleviated the problem.

The production results for the three Latin squares combined are presented in Table 3. Similar trends were observed in all squares. Average milk fat percent before the trial began was 3.9% and 3.6% for the cows and heifers respectively. After the animals were moved to the tie-stalls and put on the treatment rations, severe milk fat depression was observed (Table 3). The milk fat depression was accentuated with the addition of canola products. This could have occurred because the control ration was not limiting in fatty acids, or due to the milk fat depressing properties of the control ration. The animals gained weight throughout the experimental period despite being limited in digestible energy intake.

There was no effect of treatment on milk yield. Fat-corrected milk production was significantly higher on the control ration due to the increased yield and milk fat percentage with this diet. There was no treatment effect on the milk crude protein percentage.

The milk fat percentage was significantly lower with the heifers consuming hay compared to the cows consuming hay. The heifers on silage had a higher milk fat percentage than the heifers consuming hay.

There was no significant effect of treatment on the dry matter or acid-detergent fiber digestibility (Table 4). A trend was seen toward a reduced ADF digestibility with the added oil. This has been reported in other experiments.

Blood urea was significantly higher on the control ration when squares were analyzed together (Table 5). A comparison of urea when analyzed in the blood and milk was not different indicating that milk could be used to predict blood urea. The values for urea were consistently high, probably due to energy deficiency rather than excess protein.

The crude protein disappearance rates were the same for whole seed and presscake. Both were significantly higher than the canola meal (Table 6). The final moist heat that the canola meal is subjected to appears to reduce protein solubility. These differences did not appear to affect production.

CONCLUSION

The inclusion of canola oil these rations did not alleviate milk fat depression, regardless of the form of the addition. There was no effect of including canola products of varying crude protein solubilities on production.

Milk urea is a good predictor of blood urea. Additional research is needed to determine the practical, physiological significance of this.

IMPACT ON THE INDUSTRY

The results of this study indicate that adding canola oil to a dairy cow's ration is not a feasible method of increasing the efficiency of milk fat production. Additional research is needed to determine if the lack of response in this set of experiments can be attributed only to the milk fat depressing properties of the control ration.

The use of supplements with varying crude protein solubilities does not affect milk production if the rations are not initially limiting in total protein.

Table 1. Nutrient Composition of Canola Presscake
(%, as is)

	Canola presscake	Canola meal[a]	Soybean meal[a]
Dry matter	94[b]	92	89
Crude protein	33[b]	40	50
Ether extract	21[b]	2.0	1.3
Acid Detergent fiber	18[c]	21	10
Calcium	0.55[c]	0.58	0.31
Phosphorus	0.84[c]	0.90	0.70

[a] NRC (1978).

[b] Average values from 7 Western Canadian crushing plants. (Bell, unpublished)
Range - Crude protein 27.68 to 36.49
- Ether extract 17.48 to 26.67

[c] Average values from presscake used in this trial.

Table 2. Concentrate ingredients (%)[a]

Ingredient	Control	Canola Oil	Press Cake	Whole Canola
	Cow-hay and heifer-hay squares[b]			
Barley	75	70	72	69
Soybean meal	2	3	-	3
Canola meal	17	17	-	12
Canola oil	-	3.5	-	-
Canola presscake	-	-	22	-
Whole canola seed	-	-	-	9
Molasses	2	2	3	3
Minerals[c]	3	3	3	3
Salt	.8	.8	.8	.8

[a] Columns do not equal 100% due to rounding.

[b] Heifer-silage square similar with increased minerals to compensate for the low levels in the silage.

[c] Consisting of dicalcium phosphate and a prepared supplement added to the concentrate at 1% (as fed).

Table 3. Milk production data. Combined squares.

	Control	Canola Oil	Press cake	Whole Canola	SEM
Actual yield (kg/day)	28.9	27.9	28.8	28.4	.77
Milk fat (%)	2.69[a]	2.32[b]	2.54[ab]	2.39[b]	.08
4% FCM yield (kg/day)	23.0[a]	20.7[c]	22.2[ab]	21.5[bc]	.57
Crude protein (%)	3.07	3.08	3.07	3.19	.05
Crude protein (g/day)	879	858	879	900	23.27
Total solids (%)	11.5[a]	11.1[b]	11.5[a]	11.5[a]	.09

[1] Standard error of means

a,b,c, Means in the same row with different superscript letters are significantly different ($P<0.05$).

Table 4. Ration digestibility values (Lignin Ratio Method).

	Control	Canola Oil	Press cake	Whole Canola	SEM[1]
	Cow-hay and heifer-hay squares (%)				
Dry matter	66.4	66.6	65.1	66.0	0.66
Gross energy	64.6	63.6	66.3	66.5	0.66
Crude protein	72.7	69.6	71.9	71.2	0.79
Acid detergent fiber	28.1	23.0	28.2	28.5	1.19
Ether extract	60.4[a]	69.8[ab]	73.6[b]	68.7[ab]	1.60

[1] Standard error of means

a,b,c, Means in the same row with different superscript letters are significnatly different (P<.05).

Table 5. Blood and milk urea (mmol/L).

	Control	Canola Oil	Press cake	Whole Canola	SEM[1]
			Blood		
Combined squares	6.50	6.03	5.91	6.47	.12
Cow-hay square	6.03	5.93	5.93	6.80	.24
Heifer-silage square	6.60	6.13	5.90	5.95	.19
Heifer-hay square	6.88	6.03	5.90	6.65	.21
			Milk		
Heifer-hay square	5.93	5.73	5.98	6.30	.10

[1] Standard error of means

Table 6. Disappearance from rumen incubated nylon bags.

(Cumulative %)

Hour	Whole Seed	Presscake	Canola Meal	SEM[1]
		Dry matter		
4	58.8[a]	59.0[a]	47.0[b]	.8
8	81.6[a]	77.1[b]	62.8[b]	1.1
12	89.8[a]	83.4[b]	71.1[c]	1.0
		Crude protein		
4	70.2[a]	71.1[a]	50.1[b]	1.3
8	87.4[a]	86.3[b]	65.8[b]	1.4
12	93.5[a]	91.1[a]	75.1[b]	1.1

[1] Standard error of means

a,b,c, Means in the same row with different superscript letters are significantly different ($P<0.05$).

Technical Report: SARF Grant 5-84-30

Evaluation of Protein Status of Lactating Dairy Cows

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Abstract

This project was conducted to evaluate milk urea nitrogen analysis as a method of assessing protein status of dairy cattle. Blood urea nitrogen analysis has been found to be related to protein intake and the quality of protein in a dairy cow ration. Blood urea nitrogen is not, however, suitable for routine evaluation of the status of individual cows and of herds. In this project, two rations, one adequate and one deficient in protein were fed to cows in the University of Saskatchewan herd. The rations were based on barley, soybean and canola meal and barley silage was the forage source comprising 45% of the ration dry matter. The adequate crude protein ration maintained a slightly higher milk yield (30.7 kg daily) than the low protein ration (29.0 kg daily). Milk urea was higher on the high protein ration and was correlated with protein intake. It was concluded that milk urea nitrogen may be a useful screening tool to identify herds or individual cows which are not receiving sufficient protein.

Background

Plasma urea measurement at specified time intervals after feeding is an experimental method of measuring nitrogen (protein) utilization by dairy cows. It is a measure of surplus protein following the absorption of ammonia from the rumen. High blood urea levels result from protein (or NPN) intakes which meet or exceed the cows requirement. Low urea levels result from low protein intake. Total dietary protein intake, level of bypass protein, amount of non-protein nitrogen (NPN) in relation to total protein intake and the dietary energy level are the most important factors that cause fluctuations in plasma urea content. Abrupt ration changes, restriction and time of sampling in relation to time of feeding can also affect plasma urea levels. Under well controlled experimental conditions plasma urea levels may give some indication of adequacy of protein intake for a group of cows.

There is limited data available concerning the use of milk urea content as a measurement of nitrogen utilization. Milk samples can be more readily collected than plasma samples. Milk urea also serves as an accurate continuous method of sampling blood urea during milk synthesis.

Objectives

1) To determine the effect of total dietary protein (natural source) on milk production and composition, feed intake and efficiency and bodyweight change.

2) To measure plasma and milk urea levels of cows fed low and adequate amounts of dietary crude protein.

Experimental Method

Four mature dairy cows were fed in a double switchback design trial with three 21 day feeding periods. Two concentrates, designated as low protein or adequate protein, were formulated (Table 1). The protein sources were soybean and canola meal. These are relatively low bypass proteins which means only a small percentage of the protein escapes rumenal degradation. Protein from barley grain is also low bypass. Concentrates were fed with barley silage in a 55:45 concentrate:forage HE ratio. Total ration dry matter protein content was formulated to 13% (low) and 14.5% (adequate).

Milk samples were collected on three consecutive days at the end of each period. Morning and evening samples were mixed and daily samples were submitted to the clinical pathology laboratory (Western College of Veterinary Medicine) for milk urea analyses. Jugular blood samples were drawn on the last day of each period for urea analyses.

Results and Discussion

The crude protein content of the silage averaged 13% of the dry matter but varied substantially between periods (Table 2). The crude protein content of the total ration, although not constant, was low or adequate according to concentrate fed, throughout the three periods.

Total crude protein intake (Table 3) was calculated on a per period basis using actual feed intakes and ration analyses. The low CP ration met 95% of the cows' protein requirement (National Research Council, 1978) while 108% of their requirement was provided by the adequate protein ration. These percentages were slightly higher than anticipated. This was due to the fact that milk fat content was lower than expected

thereby lowering the total protein requirement of cows producing at the noted levels of milk production (Table 4).

Milk yield and fat percentage did not differ for the two levels of ration protein although both tended to be higher on the adequate protein ration (Table 4). This resulted in higher ($P<0.10$) production of 4% fat corrected milk by the cows fed the adequate level of protein. There were no differences in milk crude protein content. Cows fed the low protein ration produced as much milk protein as cows fed the adequate ration. Milk fat levels were low on both rations. This was partly due to feeding pelleted concentrates and partly due to a high proportion of concentrate in the ration (Table 5).

Ration protein level did affect feed intake (Table 5). The low protein fed cows consumed significantly less ($P<0.05$) feed dry matter than cows fed adequate levels of crude protein and resulted in similar slight increases in body weight. All cows were offered ration to appetite. The low protein cows ate a larger proportion of the concentrate portion of the ration. This is reflected by concentrate dry matter intake as a percent of total dry matter intake. The ration was designed to be fed at a 55:45 concentrate:forage HE ratio. Actual intakes resulted in a 60:40 ratio which was partially responsible for the depressed milk fat percentages by reducing total fibre intake. The adequate protein ration was slightly more efficient requiring less feed dry matter to produce 100 kg of 4% fat corrected milk.

Plasma and milk urea levels were significantly lower ($P<0.05$) from cows fed the low protein ration (Table 6). Milk urea levels were lower than plasma urea levels for both rations. This difference may be due to sampling time. Blood samples were collected 2 hours post feeding which

theoretically should result in the highest levels of urea. Milk samples were collected prior to feeding. Milk urea as a percent of plasma urea did not give a constant value for both rations with the percentage being lower ($P<0.05$) on the low CP ration. Total milk urea (milk urea, mmol/L x L milk produced) was significantly lower ($P<0.05$) for the low protein ration. Conversely, it required more ($P<0.10$) total dietary protein intake to produce a mmol of milk urea with the low protein ration. This may be taken as an indication of more efficient use of available protein with less lost as urea.

Conclusions

Production was not affected in the short term by feeding 5% below the total protein requirement. Appetite was depressed by the low protein ration indicating a probable effect on production over a longer time frame.

Milk urea content did reflect total protein intake although a definite correlation to plasma urea could not be made. Milk urea also indicated a more efficient use of available protein by cows fed the low protein ration. This confirms the fact that rations containing low levels of bypass protein are used more efficiently at lower levels.

Impact on the Industry

Cows fed rations containing less than adequate protein levels will exhibit depressed appetites.

Measuring milk urea gives a reasonable estimate of a cows' protein status.

Table 1. Concentrate[1] ingredients, % air dry

	Low CP concentrate	High CP concentrate
Barley	86.0	75.9
Soybean meal	3.0	8.2
Canola meal	3.0	8.2
Molasses	3.0	3.0
Dicalcium phosphate[2]	1.7	1.4
Limestone	1.5	1.5
Cobalt-iodized salt	0.8	0.8
Mineral-Vitamin premix[3]	1.0	1.0

[1] The concentrate portion of the ration was pelleted (4.7 mm diameter).

[2] Calcium (15% min) and phosphorus (21%) source.

[3] To supply 13,200 IU Vitamin A, 1,100 IU Vitamin D, 11 IU Vitamin E, 20 mg manganese, 40 mg zinc and 12 mg copper per kg of concentrate.

Table 2. Chemical composition[2] of concentrate and silage fed

		% in dry matter				
	% DM	CP	Ca	P	K	ADF
Low CP concentrate	86.7	12.6	.92	.70	.58	
High CP concentrate	86.6	16.1	.99	.72	.78	
Barley silage	33.0	13.0[2]	.54	.35	1.50	32.8

[1] From laboratory analysis.

[2] The crude protein content of the barley silage varied from period I to period II: 13.1% (I), 14.3% (II) and 11.9% (III).

Table 3. Crude protein intake

	Low CP Ration	Adequate CP Ration	$SE_{\bar{x}}$
CP requirement, g/day	2586_{A}	2726_{B}	50.8
CP intake, g/day	2415^{A}	2925^{B}	25.4
CP intake, % CP req't	95.0^{a}	108.1^{b}	2.3

A-B Means in the same row followed by different superscript letters are significantly different ($P<0.01$).

a-b ($P<0.05$)

Table 4. The effect of ration protein level on milk yield and composition

	Low CP Ration	Adequate CP Ration	$SE_{\bar{x}}$
Milk yield, kg/day	29.0	30.7	.83
Milk fat, %	2.33	2.45	.09
Milk fat, kg/day	.68	.75	.02
4% fat corrected milk, kg/day	21.9^{1}	23.5^{2}	.50
Milk protein, %	2.94	2.98	.05
Milk protein, kg/day	.85	.90	.02
Milk total solids, %	10.64	10.74	.12

1-2 Means in the same row followed by different superscript numbers are significantly different ($P<0.10$).

Table 5. The effect of ration protein level on feed intake and utilization

	Low CP Ration	Adequate CP Ration	$SE_{\bar{x}}$
Concentrate DM intake, kg/day	11.5^{1}	11.6^{2}	.04
Silage DM intake, kg/day	7.5^{1}	8.1^{2}	.15
Total DM intake, kg/day	18.9^{a}	19.6^{b}	.17
Concentrate DM. % total DM	60.8^{1}	59.3^{2}	.46
Feed DM/100 kg 4% fcm, kg	88.7	85.0	3.43
Bodyweight change, g/day	495	275	258

1-2 Means in the same row followed by different superscript numbers are significantly different ($P<0.10$).

a-b Means in the same row followed by different superscript letters are significantly different ($P<0.05$).

Table 6. The effect of ration protein level on plasma and milk urea content

	Low CP Ration	Adequate CP Ration	$SE_{\bar{x}}$
BUN, mmol/L	4.6^{a}	6.0^{b}	.28
Milk urea, mmol/L	3.4^{a}	4.9^{b}	.23
Milk urea, % of BUN	74.2^{a}	83.0^{b}	.94
Total milk urea, mmol/day	97.6^{a}	149.0^{b}	9.6
g CP intake/mmol milk urea	24.5^{1}	19.8^{2}	1.5

1-2 ($P<0.10$)

a-b ($P<0.05$)